Technology Readiness Assessment of Department of Energy Waste Processing Facilities

Kurt Gerdes, Steven Krahn — Department of Energy

Herbert Sutter — Consultant, Department of Energy

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The Department of Energy's overarching mission is to advance the national, economic, and energy security of the United States; to promote scientific and technological innovation in support of that mission; and **to ensure the environmental cleanup of the national nuclear weapons complex.**

The Office of Environmental Management (EM) is responsible for the risk reduction and cleanup of the environmental legacy of the Nation's nuclear weapons program, one of the largest, most diverse, and technically complex environmental programs in the world.

EM has annual appropriations of ~ $6-7 B and is responsible for:

- Cleanup and/or closure of sites;
- Constructing and operating facilities to treat radioactive liquid tank waste into a safe, stable form to enable ultimate disposition;
- Securing and storing nuclear material in a stable, safe configuration in secure locations to protect national security;
- Transporting and disposing of transuranic and low-level wastes in a safe and cost-effective manner to reduce risk.

Waste Treatment Involves Chemical Processing.

Feed → A → B → C → D → E → Product

	CHEMICAL INDUSTRY	DOE EM
FEED	Uniform – Well Defined	Poorly Characterized - Variable
OUTPUT	Uniform – Well Specified	Composition Variable
PREVIOUS EXPERIENCE	Multiple Plants	One of a Kind
MAINTENANCE	Hands On	Remote/None
OPERATIONS	Hands On	Remote
RECONFIGURATION	Relatively Easy	Extremely Difficult
PROCESS REFINEMENT	On the Fly	Extremely Difficult

Waste Treatment Facilities Must Be Reliable, Robust, Flexible, and Durable.

The DOE TRA/TMP Methodology Is Based On That Of DoD/NASA.

- The DOE TRA/TMP Guide is based on DoD/NASA documents.
- The TRA process uses standard definitions for TRLs with some adaptation for chemical processing.
- The process uses independent experts.
- The process uses the questions in the Nolte Calculator. Some Calculator questions have been modified, and some process questions have been added.
- The process accepts only documented responses.

DOE TRL Working Definitions Are Adapted for Chemical Processing.

- **Scale**
  - Full Plant Scale — Matches final application
  - Engineering Scale — **Typical** (1/10 < system < Full Scale)
  - Laboratory/Bench Scale — < 1/10 Full Scale

- **System Fidelity**
  - Identical System Configuration - matches final application in all respects
  - Similar System Configuration - matches final application in almost all respects
  - Pieces - System matches a piece or pieces of the final application
  - Paper - System exists on paper - no hardware system

- **Environment (Waste)**

Operational (Full Range)	Full range of actual waste
Operational (Limited Range)	Limited range of actual waste
Relevant	Simulants + a limited range of actual wastes
Simulated	Range of simulants

DOE TRL Testing Requirements

TRL Level	Scale of Testing	Fidelity	Environment
9	Full	Identical	Operational (Full Range)
8	Full	Identical	Operational (Limited Range)
7	Full	Similar	Relevant
6	Engineering/Pilot Scale	Similar	Relevant
5	Lab/Bench	Similar	Relevant
4	Lab	Pieces	Simulated
3	Lab	Pieces	Simulated
2		Paper	
1		Paper	

Additional Process Chemistry Questions

TRL	Criteria
5	The range of all relevant physical and chemical properties has been determined (to the extent possible)
	Simulants have been developed that cover the full range of waste properties
	Testing has verified that the properties/performance of the simulants match the properties/performance of the actual wastes
	Laboratory scale tests on the full range of simulants using a prototypical system have been completed
	Laboratory scale tests on a limited range of real wastes using a prototypical system have been completed
	Test results for simulants and real waste are consistent
	Laboratory to engineering scale scale-up issues are understood and resolved
	Limits for all process variables/parameters are being refined
	Test plan for prototypical lab scale tests executed – results validate design
	Test plan documents for prototypical engineering scale tests completed

	Characterization		Testing		Process limits
	Simulants		Scale up issues		Test plans

Even Bad News Is Better Than No News
Case 1: Hanford K-Basins
June, 2007

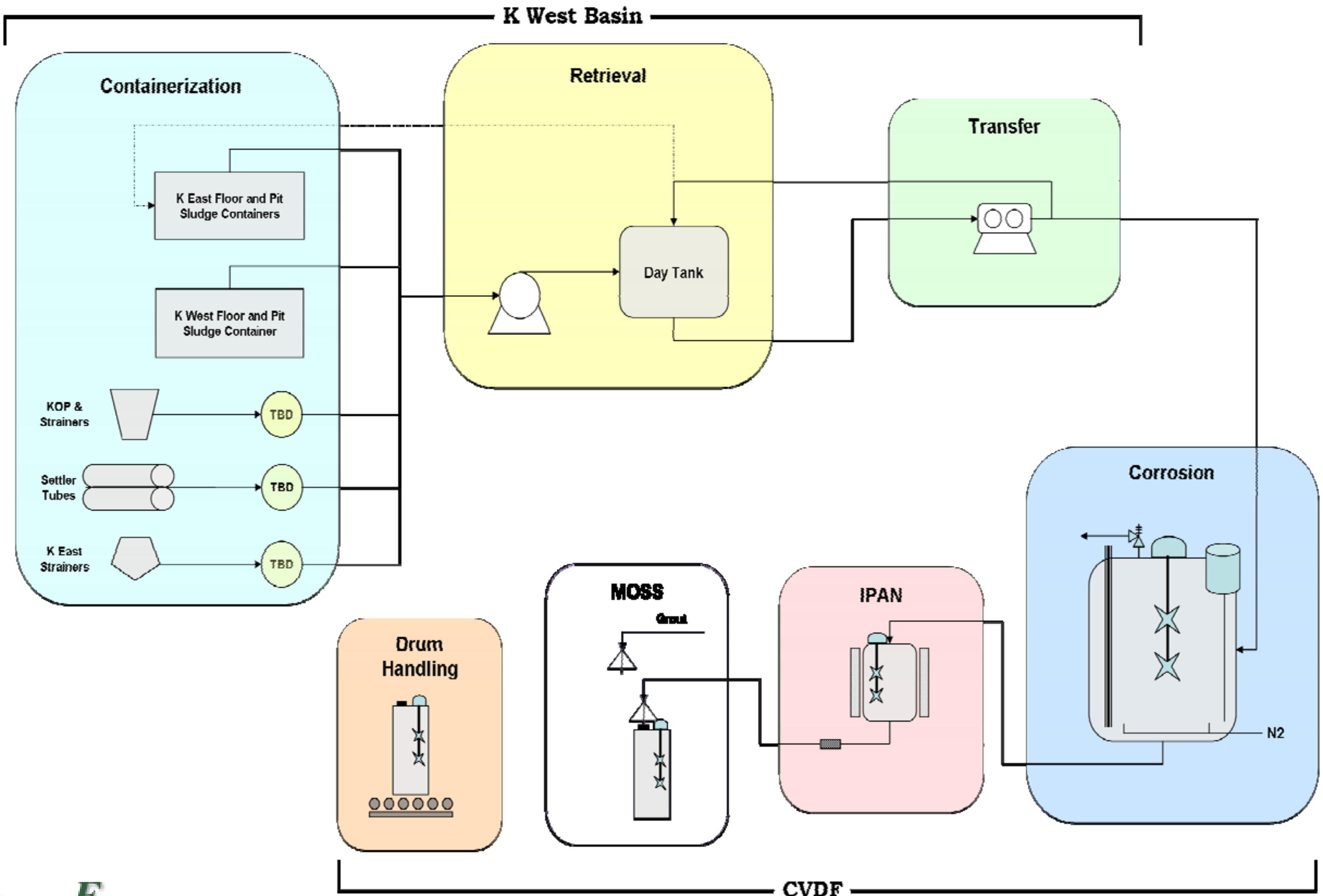
Project: Removal of sludge from K Basins spent fuel storage pools.

Technologies: sludge containerization, retrieval, transfer, oxidation, assay, packaging, and drum handling.

Prior to TRA: Project preparing to move to procurement and construction.

Post TRA Status: Project returned to conceptual design and reconsideration of alternatives.

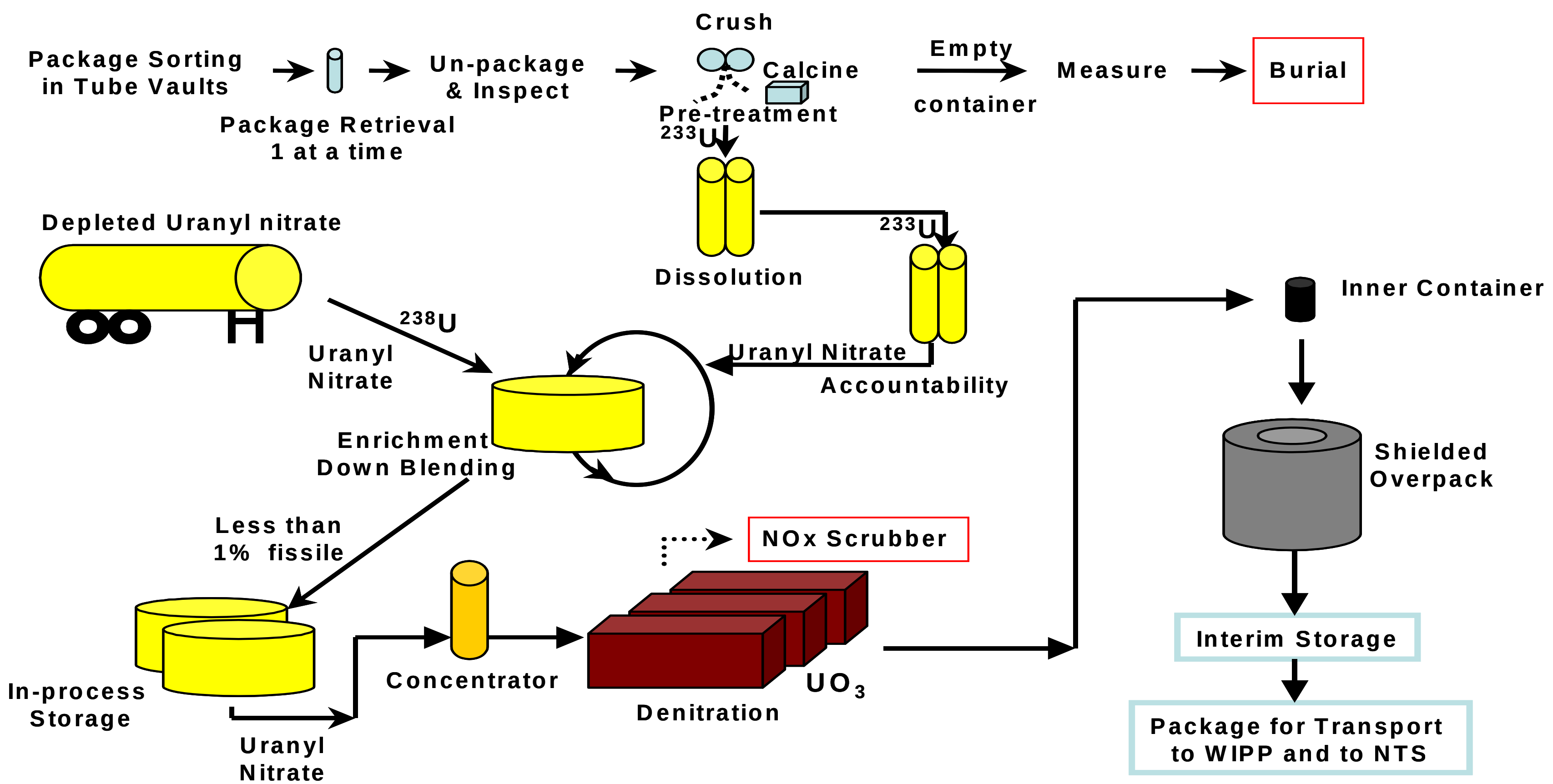
K-Basins Sludge Process Flow



Of Seven K-Basins Technologies Three Were At TRL 4, Four Were At TRL 2.

TECHNOLOGY	TRL
Sludge Mobilization And Retrieval	2
Sludge Transfer Between Unit Operations	4
Process Chemistry And Characterization	2
Process Instrumentation (Process And Safety Monitoring)	4
Assay (Quantity And Isotopic Nature Of Drummed Sludge)	2
Mixing Of Sludge And Slurries	2
Waste Packaging (Contamination Control And WIPP Certification)	4

The U-233 Downblending Process Reduces Nuclear Proliferation Risks



U-233 Downblending Process

Even Bad News Is Better Than No News
Case 2: Oak Ridge U-233 Processing
August, 2008

Project: Downblending fissile U-233 with depleted uranium (U-238) to limit proliferation risk

Technologies: Laboratory analysis, off gas treatment, concentration, and product packaging.

Prior to TRA: Project preparing to move to procurement and construction.

Post TRA Status: Project reconsidering alternatives.

Four Technologies Need Maturation, and The Product May Not Be Acceptable.

- The product may not be disposable.
- Analytical instrumentation and procedures may not meet project requirements.
- The off gas system may not reduce radioactive emissions to an acceptable level.
- A key concentration step has not been adequately demonstrated.
- Contamination may be a problem during packaging.

What We've Learned About The TRA/AD2 Process (1)

- Structured, objective, and clearly documented process ("transparent").
- The process enforces discipline on DOE and the Contractor.
- Contractors and DOE like the TRA language and formalism. Technical communication is greatly improved.
- Technologists like having standards.
- Documentation is critical
- Useful tool for comparing candidate technologies.
- Process assists in identification of specific actions needed to reduce programmatic risk to final commitment and major investment in a technology.

What We've Learned About The TRA/AD2 Process (2)

- Relevant environment (feed characterization) is critical
- Product definition/requirements are critical (DOE must do its part)
- All components must be tested, preferably in a complete system
- The calculator is useful to focus discussion on key areas
- Evaluation of process flow, connecting the technologies in a flowsheet, remains a challenge.

What We've Learned About The TRA/AD2 Process (3)

- The process has been proven very helpful even for relatively mature projects.
- It is often the peripheral technologies that are untested and ripe for problems.
- Expert team members frequently become valued contributors to future development.
- Project managers and personnel almost always think their technologies are more mature than they really are.
- Almost all project managers go from, “Is this really necessary?” to “Thank you so much.”
- It is all about helping the project/project manager succeed.

We've Made A Lot of Progress on Last Year's Next Steps

- Determine whether the process is to be required/adopted by EM and/or DOE **Process adopted/required by EM. Other DOE Organizations are moving toward adoption.**
- Develop program guidance for TRAs, TMPs, IRPs, Test Plans **Done**
- Formalize definitions and embed them in the culture **Definitions formalized, working on the culture.**
- Tie process to DOE/EM project management/acquisition strategy **Started**
- Connect process to DOE/EM risk evaluation policy **In process**
- Continue to wrestle with chemical process flow **Still a challenge**
- Disseminate information on process and train facilitators. **In process**

Back-Up

DOE Critical Decision Process

CD-O: Approve Mission Need

A Program identifies a credible performance gap between its current capabilities and capacities and those required to achieve the articulated in its strategic plan goals. Approval of CD-0 formally establishes a project and begins the process of conceptual planning and design used to develop alternative concepts and functional requirements.

CD-1: Approve Alternative Selection and Cost Range

CD-1 approval marks the completion of and provides the authorization to begin the project Execution Stage, allowing Project Engineering and Design funds to be used. For design-build projects an RFP may be prepared and long- lead procurements may be approved.

CD-2: Approve Performance Baseline

A performance baseline is developed based on a mature design, a well-defined and documented scope, a resource-loaded detailed schedule, a definitive cost estimate and defined Key Performance Parameters. A budget request is submitted for the total project cost.

CD-3: Approve Start of Construction

Approval of CD-3 authorizes the project to commit all resources necessary, within the funds provided, to execute the project.

CD-4: Approve Start of Operations or Project Completion